a shaft linked to a set of road wheels, the shaft including a slot parallel to the axis of the shaft and located at a single peripheral location about the surface of the shaft;

a piezoresistive sensor positioned within and along the length of the slot and responsive as a cantilever beam to torque applied to the shaft and operative thereby to provide as output a signal indicative of the applied torque;

a controller in signal communication with the sensor and operative thereby to accept as input from the sensor the signal indicative of the torque applied to the shaft; and

a motor coupled to the shaft and in signal communication with the controller and operative thereby to accept as input from the controller a command to apply torque to the shaft.

**Claim 3 is presented below in clean form:**

3. (Amended) The automotive steering system as set forth in Claim 1 wherein the piezoresistive sensor comprises at least one piezosensitive element coupled to a ceramic substrate.

Cancel Claims 26-32.

## REMARKS

### Procedural Posture

Claims 1 – 32 are pending in the application. Of Claims 1 – 32, Claims 10 – 25 have been withdrawn from consideration. Claims 1 – 9 and 26 – 32 stand rejected.

### 35 U.S.C. § 112

Claims 27 – 32 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 27 – 32 have been cancelled.

### 35 U.S.C. § 102(b)

Claims 1, 2 and 9 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Yamamoto (5,010,970). A claim is anticipated, and therefore invalid under 35 U.S.C. § 102, if each claimed element is found in a single prior art reference. *Scripps Clinic & Research Foundation v. Genentech, Inc.*, 927 F.2d 1565, 1576 (Fed. Cir. 1991); *Carella v. Starlight Archery and Pro Line Co.*, 804 F.2d 135, 138 (Fed. Cir. 1986). There must be no difference between the claimed invention and the reference disclosure, as viewed by an ordinary artisan. *Scripps Clinic & Research Foundation v. Genentech, Inc.*, 927 F.2d at 1576.

With regard to Claim 1, Yamamoto teaches a "torque detector 37, which is a potentiometer or a *sliding contact resistor* device (emphasis added)." (*Col. 5, lines 54 – 55, Fig. 2; Col. 9, lines 54 – 56, Fig. 11*). In such potentiometer or sliding contact resistor device, "when a steering torque imparted to the steering wheel 3 is so great that it will cause a slippage of the driven steering drum 6 relative to the drive steering disk 10 against the torsion springs 26 and 27, the torque detector 37 generates an electric signal proportional to the angular position of the drive steering disk 10 relative to the driven steering drum 6." (*Col. 5, lines 62 – 68*). The determination of torque using a potentiometer is based upon an electrically conductive wiper that moves along a resistive element subject to known voltage, thus establishing a voltage divider circuit. The torque detector of Yamamoto requires slippage, or relative motion, between two mechanical parts to determine the torque acting upon a shaft. In addition, the detector of Yamamoto does not rely upon the detector itself undergoing some physical distortion in measuring the torque acting upon the shaft.

In stark contrast, Claim 1, as amended, recites a *piezoresistive* sensor positioned within a slot in a shaft and responsive as a *cantilever beam* to torque applied to the shaft. The sensor of Claim 1 relies upon the piezoelectric effect whereby certain materials will produce a voltage when subject to some deformation. Such deformation suffered by the sensor of Claim 1 is in the nature of a cantilever beam.

Therefore, the Applicant respectfully submits that claim 1, as amended, clearly distinguishes over Yamamoto and stands in condition for allowance. Notification of this fact is respectfully requested. Claims 2 and 9 depend from Claim 1 and are therefore allowable for at least the same reasons as set forth for Claim 1.

Claims 1, 2 and 9 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Brier (2,754,465). With regard to Claim 1, Brier teaches "a plurality of mechanical stress sensitive resistor elements 48 known as strain gages, connected in a bridge circuit." (*Col. 2, lines 46 – 48, Figs. 2, 3, 5 and 6*). The aforesaid "strain gages are mounted at angles of approximately 45 degrees to the direction of the axis of"a part (*14*) of a steering column. (*Col. 2, lines 53 – 54, Figs. 2, 5 and 6*). As also can be seen in Figures 2, 5 and 6, the aforesaid strain gages are attached to part *14* at the *surface* thereof. Thus, Brier teaches strain gages mounted on the surface of a shaft and positioned *at an angle* of approximately 45 degrees with respect to the axis of the shaft.

In stark contrast, Claim 1, as amended, recites a shaft including a slot *parallel to the axis of the shaft* and located at a single peripheral location about the surface of the shaft; as well as a piezoresistive sensor positioned within and *along the length of the slot* and responsive as a cantilever beam to torque applied to the shaft and operative thereby to provide as output a signal indicative of the applied torque. The responsive nature of a cantilever beam is contrary to that of a strain gage.

Therefore, the Applicant respectfully submits that claim 1, as amended, clearly distinguishes over Brier and stands in condition for allowance. Notification of this fact is respectfully requested. Claims 2 and 9 depend from Claim 1 and are therefore allowable for at least the same reasons as set forth for Claim 1.

Claims 1, 2 and 9 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Taig (4,655,092). With regard to Claim 1, Taig teaches slots *62*, *100* and *76* in an input member *16* and a slot *64* in an output member *18*. (*Fig. 2*). Taig also teaches a torsion member *20* whereby the torsion member *20*, the input and output members *16, 18* and the aforesaid slots *62, 100, 76, 64* are mechanically engaged during operation. When there is relative motion between the input and output members *16, 18*, the torsion member *20* flexes. (*Col. 4, lines 44 – 47, Figs. 2, 4a, 4b*). Taig further teaches that "a strain gauge 94 is fixedly secured to one of the surfaces of the torsion member 20 in conventional meaner." (*Col. 4, lines 7 – 9*). Still further, Taig teaches "that torque applied to the input member 16 will produce direct mechanical coupling of the torque to the output member 18 through the torsion member 20. This torque will further effect strain in the torsion member 20 which is a function of the torque applied

therethrough. This torque is converted to an electrical signal by means of the strain gage or other strain sensing elements 94." (*Col. 4, lines 35 – 42*). As seen in Figures 4a and 4b the slots *62, 100, 76, 64* of the input and output members *16, 18* actually comprise two slots located in the wall of the input and output members diametrically apposed to one another. The two slots are a *necessity* in order that the torsion member *20* be allowed to fit within the slots *62, 76, 100* of the input member *16* and to thereby mechanically engage the output member *18* through slot *64*. The relative motion of the input member *16* with respect to the output member *18* causes the torsion member to twist or suffer *torsion*, from which the torque acting upon the column can be determined.

In stark contrast, Claim 1, as amended, recites a shaft including a slot parallel to the axis of the shaft and located at a *single* peripheral location about the surface of the shaft. The slot of Claim 1 receives a piezoresistive sensor within and along the length of the slot. The piezoresistive sensor so positioned is thus responsive, as a *cantilever beam*, to torque applied to the shaft.

Therefore, the Applicant respectfully submits that claim 1, as amended, clearly distinguishes over Taig and stands in condition for allowance. Notification of this fact is respectfully requested. Claims 2 and 9 depend from Claim 1 and are therefore allowable for at least the same reasons as set forth for Claim 1.

35 U.S.C. § 103(a)

Claims 3 - 8 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Brier in view of Brosh et al (5,398,194). Applicants traverse the rejection of Claims 3 – 8 for the following reasons.

For an obviousness rejection to be proper, the Examiner must meet the burden of establishing a *prima facie* case of obviousness. *In re Fine*, U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988). The Examiner must meet the burden of establishing that all elements of the invention are disclosed in the prior art; that the prior art relied upon, coupled with knowledge generally available in the art at the time of the invention, must contain some suggestion or incentive that would have motivated the skilled artisan to modify a reference or combine references; and that the proposed modification of the prior art must have had a reasonable expectation of success,

determined from the vantage point of the skilled artisan at the time the invention was made. *In re Fine*, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988); *In re Wilson*, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970); *Amgen v. Chugai Pharmaceuticals Co.*, 927 U.S.P.Q.2d, 1016, 1023 (Fed. Cir. 1996). Moreover, the mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990).

Amended Claim 3 depends from Claim 1. Brier is replete with the teaching of strain gages. (*Col. 2, line 44 – Col. 5, line 33*). Brier also teaches that "the strain gages are *mounted at angles of approximately 45 degrees to the direction of the axis of "a part (14) of a steering column.* (*Col. 2, lines 53 – 54, Figs. 2, 5 and 6*). As also can be seen in Figures 2, 5 and 6 of Brier, the aforesaid strain gages are attached to part 14 *at the surface* thereof. Thus, Brier teaches strain gages mounted on the surface of a shaft and positioned at an angle of approximately 45 degrees with respect to the axis of the shaft. Brosh teaches "A Wheatstone bridge circuit 30 has four piezoresistor elements 32, 34, 36, 38 arranged in two bridge legs connected in parallel between a first pair of bridge points J1 and J2. Each bridge leg has two piezoresistor elements connected in series, i.e., piezoresistor elements 32, 38 and elements 34, 36 respectively. A second pair of bridge points J3 and J4 are the connection points between the piezoresistor elements of the respective bridge legs." (*Col. 2, line 11 – 19*).

Neither Brier, nor Brosh et al, either alone or in combination, teach or even suggest the recitation of Claim 3, including a piezoresistive sensor *positioned within and along the length of a slot parallel to the axis of a shaft* and responsive, as a cantilever beam, to torque applied to the shaft and operative thereby to provide as output a signal indicative of the applied torque; wherein the piezoresistive sensor comprises at least one piezosensitive element coupled to a ceramic substrate.

Thus it would not have been obvious to one skilled in the art at the time the invention was made to arrange the resistors of Brier in a Wheatstone bridge as taught by Brosh nor to use piezoresistors. For the reasons above, the Examiner's rejection of Claim 3 should be withdrawn. Applicant's respectfully submit that Claim 3 is patentable over Brier in view of Brosh et al and therefore should be allowed. Claims

4 - 8 variably depend from Claim 3, and should be allowed for at least the same reasons.

Claims 3 - 8 and 26 – 32 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Taig in view of Brosh et al. Claims 26 – 32 have been cancelled. Applicants traverse the rejection of Claims 3 – 8 for the following reasons.

Amended Claim 3 depends from Claim 1. Taig teaches a torsion member *20* whereby the torsion member *20*, input and output members *16, 18* and slots *62, 100, 76, 64* are mechanically engaged during operation and when there is relative motion between the input and output members *16, 18*, the torsion member *20* flexes. (*Col. 4, lines 44 – 47, Figs. 2, 4a, 4b*). Taig further teaches that "a strain gauge 94 is fixedly secured to one of the surfaces of the torsion member 20 in conventional meaner." (*Col. 4, lines 7 – 9*). Still further, Taig teaches "that torque applied to the input member 16 will produce direct mechanical coupling of the torque to the output member 18 through the torsion member 20. This torque will further effect strain in the torsion member 20 which is a function of the torque applied therethrough. This torque is converted to an electrical signal by means of the strain gage or other strain sensing elements 94." (*Col. 4, lines 35 – 42*). As seen in Figures 4a and 4b the slots *62, 100, 76, 64* of the input and output members *16, 18* comprise two slots located in the wall of the input and output members and diametrically apposed to one another. The two slots are a *necessity* in order that the torsion member *20* be allowed to fit within the slots *62, 76, 100* of the input member *16* so as to thereby mechanically engage the output member *18* as noted above. Because the torsion member *20* spans the input and output members *16, 18,* (see Figs. 4a and 4b) the relative motion of the input member *16* with respect to the output member *18* causes the torsion member *20* to *twist* or suffer torsion, from which the torque acting upon the column can be determined. Thus, the torsion member 20 responds to torque applied to the input and output members *16, 18* in torsion and *not as a cantilever beam* as in the present invention.

Brosh teaches "A Wheatstone bridge circuit 30 has four piezoresistor elements 32, 34, 36, 38 arranged in two bridge legs connected in parallel between a first pair of bridge points J1 and J2. Each bridge leg has two piezoresistor elements connected in series, i.e., piezoresistor elements 32, 38 and elements 34, 36 respectively. A second

pair of bridge points J3 and J4 are the connection points between the piezoresistor elements of the respective bridge legs." (*Col. 2, line 11 – 19*).

Neither Taig, nor Brosh et al, either alone or in combination, teach or even suggest the recitation of Claim 3 including a slot parallel to the axis of a shaft and located at a single peripheral location about the surface of the shaft; a piezoresistive sensor positioned within and along the length of the slot and responsive *as a cantilever beam* to torque applied to the shaft and operative thereby to provide as output a signal indicative of the applied torque; wherein the piezoresistive sensor comprises at least one piezosensitive element coupled to a ceramic substrate.

Thus it would not have been obvious to one skilled in the art at the time the invention was made to arrange the resistors of Taig in a Wheatstone bridge, as taught by Brosh, nor to use piezoresistrors. For the reasons above, the Examiner's rejection of Claim 3 should be withdrawn. Applicant's respectfully submit that Claim 3 is patentable over Taig in view of Brosh et al and therefore should be allowed. Claims 4 - 8 variably depend from Claim 3, and should be allowed for at least the same reasons.

Care has been taken that no new matter has been added to the present application due to these amendments.

In view of the foregoing points that distinguish Applicant's invention from those of the prior art and render Applicant's invention definite and not obvious, Applicant respectfully requests that the Examiner reconsider the present application, remove the rejections, and allow the present application to issue.

If the Examiner believes that a telephone conference with Applicant's attorneys would be advantageous to the disposition of this case, the Examiner is invited to telephone the undersigned.

If there are any additional charges with respect to this response or otherwise, please charge them to Deposit Account No. 06-1130 maintained by applicant's attorney.

Respectfully submitted,
SCHROEDER T. et al
CANTOR COLBURN LLP
Applicant's Attorneys

By: _____
George J. Lyman
Registration No. 44,884
Customer No. 23413

Date: October 1, 2001
Address: 55 Griffin Road So.
Bloomfield, CT 06002
Telephone: (860) 286-2929

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| APPLICANT: | SCHROEDER, ET AL | ) |
| | | ) Group Art Unit |
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| | | ) Examiner: |
| FILED: | September 15, 2000 | ) D. DePumpo |
| | | ) |
| FOR: | PIEZORESISTIVE TORQUE SENSOR | ) |

**A marked up version of Claim 1 is set forth below:**

1. (Amended) An automotive steering system comprising:

a shaft linked to a set of road wheels, the shaft including a slot parallel to the axis of the shaft and located at a single peripheral location about the surface of the shaft;

a piezoresistive sensor [connected to the shaft] positioned within and along the length of the slot and responsive as a cantilever beam to [for sensing] torque applied to the shaft and operative thereby to provide as output a signal indicative of the applied torque;

a controller in signal communication with the sensor and operative thereby to accept as input from the sensor the signal indicative of the torque applied to the shaft; and

a motor coupled to the shaft and in signal communication with the controller and operative thereby to accept as input from the controller a command to apply torque to the shaft.

**A marked up version of Claim 3 is set forth below:**

3. (Amended) The automotive steering system as set forth in Claim[2] 1 wherein the piezoresistive sensor comprises at least one piezosensitive element coupled to[the shaft] a ceramic substrate.